Mathematics Learning Assistantships and Undergraduate Students' Identity Development

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Increasing the participation and achievement of students in science, technology, engineering, and mathematics (STEM) in PK-16 education continues to be a focal area of educational transformation and research. Faculty members at Institutions of Higher Education (IHE) plan, implement, and investigate how program structures can support the development, retention, and overall success of undergraduate students in STEM. Active learning classrooms, especially in mathematics, are one way IHE are reforming student learning experiences, and also provide a unique opportunity to engage undergraduate learning assistants with faculty to support near-peer students and deepen their own learning. This report examines the role of learning assistantships in developing undergraduate preservice teachers' identity while participating in a Noyce Scholarship program. Findings from this study show that preservice teacher participants gained competence in a variety of forms and developed their identity as a teacher through their experience as learning assistants in active learning classrooms.

Keywords: Teacher Preparation, Mathematics Education, Learning Assistants

Teacher attrition rates in the United States (U.S.) are approximately 8% annually. However, the highest rate of teacher attrition takes place in high-needs schools and turnover rates for mathematics and science teachers are nearly 70% greater in low socioeconomic schools (Carver-Thomas & Darling-Hammond, 2019). In 2017, 47 states and Washington D.C. identified shortages in qualified mathematics teachers (U.S. Department of Education Office of Postsecondary Education). Additionally, enrollment in teacher preparation programs has declined by more than one third since 2010 (Partelow, 2019). These factors not only contribute to the teacher shortage, but also to a lack of highly qualified, experienced teachers in classrooms. Kini and Podolsky (2016) found that teacher experience is associated with increased student achievement, highlighting the importance of teacher retention. Conversely, recruitment and retention challenges result in approximately 40% of new STEM (science, technology, engineering, mathematics) teachers entering the profession underprepared, yet they are the most likely to teach in high-needs schools, serving a majority of historically marginalized populations of students (Carver-Thomas, 2018; Carver-Thomas & Darling-Hammond, 2019; Sutcher et al., 2016). Teachers who receive less pedagogical training are more likely to leave teaching—especially in mathematics and science (Ingersoll et al., 2012).

This report examines an effort made by a mid-sized, urban university to recruit, train, and retain highly qualified secondary mathematics teachers. The project, supported by a National Science Foundation Noyce Track 1 grant (# 1852908), engages undergraduate dual-major mathematics and secondary education preservice teachers (PSTs). Within the program model, students serve as learning assistants (LAs) in active learning mathematics courses with the support of faculty mentors. In this research report, we utilize Chickering's Seven Vectors of Identity Development framework (Chickering, 1969; Chickering & Reisser, 1993) to answer the following research question: How do learning assistantships in active-learning mathematics courses develop undergraduate students' identities as future mathematics teachers?

Literature Review

The development of undergraduate student identity has been recognized as an essential factor impacting students' knowledge/competence, habits, attitudes, dispositions, and emotions (e.g., Allen & Schnell, 2016; Grootenboer & Zevenbergen, 2008). For example, identity development in mathematics begins in early childhood education where dispositions and deeply held beliefs about a student's ability to participate and perform in areas such as mathematics is established (Aguirre et al., 2013). Factors influencing STEM identity development include content competence, the ability to showcase learning to others (performance), and recognition of competence and ability in STEM by others (e.g., Carlone & Johnson, 2007; Herrera et al., 2012). These factors reveal the multifaceted and complex nature of identity development (competence, performance, and recognition) and the interwoven nature of interpersonal interactions involved in developing individuals' social and cultural identities (Herrera et al., 2012).

For undergraduate students interested in STEM education, an entirely new PST identity formation is needed to build upon their background knowledge and experiences, dispositions, roles, and responsibilities as future teachers (Beijaard et al., 2004; Slavit et al., 2016). For example, Ball et al. (2008) posit that effective mathematics teaching requires knowledge within six different domains that encompass both subject matter and pedagogical content knowledge. Not only must teachers deeply understand mathematics content, they must also be familiar with specialized mathematical content knowledge required for teaching and be able to employ effective teaching practices, both content and non-content specific. The K-12 teacher identity literature based across grade bands and contexts are well represented (e.g., Flores & Day, 2006; Friesen & Besley, 2013; Obenchain et al., 2016); however, STEM teacher identity development is still a growing area of educational research due to the increasing workforce demands and changing instructional expectations of STEM teachers to more actively engage students.

Classroom-based practicum experiences have been shown to strengthen some aspects of teacher preparation, yet many key qualities of effective teachers need to be addressed beyond PSTs' technical knowledge of content and for teaching (Banks et al., 2005). PSTs must have "wider-professional experiences" (WPEs) that allow them to consciously grapple and engage with their own attitudes and expectations on teaching and learning and to develop, enact, and reflect on their own professional knowledge in new contexts (Darling-Hammond & Bransford, 2005; Sleeter, 2018). For example, 21st century STEM teachers are called to create active learning environments where students engage deeply with content and collaborate with peers, as instructors uplift student thinking in an equitable learning space (Laursen & Rasmussen, 2019). Despite this aspiration, memorization and lecture-based instruction are still cited as the most commonly used approaches in STEM classrooms (Eurydice, 2015). Preparing PSTs to implement student-centered, active learning environments on their own requires them to experience learning and reflect on these environments through college coursework, field experiences, etc. (McDonnough & Matkins, 2010). Developing awareness through practicum and WPEs helps PSTs see what active learning looks like and how student engagement and learning can be impacted. Research has shown that undergraduates serving as learning assistants (LAs) in active learning classrooms not only shifted their understanding from unawareness to awareness of active teaching practices (Hall, 1974; Tunks & Weller, 2009), but also improved their own development of content understanding and identity, as well as enhanced their communication skills (Close et al., 2016; Goff & Lahme, 2003). Further, LAs recruited to K-12 teaching have demonstrated greater use of reform-based practices than their peers (Gray et al., 2016). While there is growing interest in exploring the processes and outcomes of embedding learning assistantships into undergraduate programs (e.g., Gomez Johnson et al., 2021; Vandergrift et al., 2020), connecting these experiences to PST development is an area of investigation that is needed to develop and retain future teachers.

Theoretical Framework

Undergraduate students undergo substantial changes in the way they think, act, and relate to others and to self during this pivotal time in their lives. Beyond cognitive development through academics, undergraduate education can be enriched by specific learning experiences and interactions in and outside of the classroom (Quinlan, 2011). Seminal work by Chickering & Reisser (1993) integrated undergraduate students' cognitive and psychosocial development theory into a model illustrating the fluid nature of student development along seven core areas, called vectors. The vectors are: developing competence, managing emotion, moving through autonomy toward interdependence, developing mature interpersonal relationships, establishing identity, developing purpose, and developing integrity. These vectors aim to define identity development as a cyclical continuation rather than a linear developmental path, later illustrated by Leggette and Jarvis (2015) as spokes on a wagon wheel to illustrate the interconnectedness of the developmental vectors. Chickering and Reisser's call to higher education institutions is to create environments that foster broad developmental practices and policies to support human talent and potential. By advancing strengths and skills along each vector, students are better equipped to overcome barriers and unexpected challenges through increased cognitive and psychosocial versatility (Chickering 1969; Chickering & Reisser 1993; Evans et al., 2010).

Research Methodology

This study investigates the ways in which engaging secondary mathematics PSTs as LAs in active learning undergraduate mathematics courses influences their development along Chickering's vectors of development. Understanding the lived experiences of the participants is well suited to qualitative research design, as we are able to collect rich and descriptive data (Charmaz, 2008; Yin, 2018) to glean how student participants "interpret their experiences and…[assign] meaning they attribute to their experiences" (Merriam, 2009, p. 5).

Context and Participants

Faculty from the institution's mathematics and teacher education departments developed a program funded by a five-year National Science Foundation Robert Noyce Teacher Scholarship Program aimed at recruiting and retaining high quality secondary mathematics teachers. Undergraduate students participating in the project are paired with a faculty mentor with whom they engage as LAs for active learning mathematics courses. Participants for this study include nine undergraduate students who participated in the program in Fall 2021. Five of the nine participants identify as female and four as male. Five out of the nine participants are upperclassmen (juniors or seniors) who have had at least one practicum experience within their traditional teacher preparation program. Fall 2021 piloted the LA experience in active learning mathematics courses uniformly with all participants.

Data Collection and Analysis

Participants completed a total of ten reflective journal entries across a 16-week semester in Fall 2021. The reflection prompts were open-ended in nature but asked the students to frame their responses around potential implications for them as future teachers. Participants agree at the onset of their acceptance to the program to allow these journals as data collection to inform the research and evaluation requirements of the program. In addition to the written reflections, the participants also take part in a focus group at the end of the fall semester. The following interview prompts were used to facilitate the semi-structured interview with the group:

1. Describe your learning assistant experience.
2. What, if anything, have you learned about mathematics? Did anything surprise you?
3. What, if anything, have you learned about teaching mathematics? Did anything surprise you?
4. What, if anything, have you learned about learners? Did anything surprise you?
5. What, if anything, have you learned about yourself after serving as a learning assistant/teaching assistant?
6. Is there anything you would change to improve your experience as a learning assistant? What advice do you have?

We used Chickering's Theory of Identity Development (Chickering, 1969; Chickering & Reisser, 1993), which is framed around seven vectors, to create a codebook. We used the codebook to engage in deductive, first round coding (Saldaña, 2021), and we added descriptive examples to the codebook to ensure the stabilization of subsequent coding across the data (MacQueen et al., 1998; Roberts, et al., 2019). We read through and coded excerpts from the participants' reflections and the focus group interview that identified moments where students referred to vector-aligned experiences/opportunities, which are: 1) developing competence, 2) managing emotions, 3) moving through autonomy toward interdependence, 4) developing mature interpersonal relationships, 5) establishing identity, 6) developing purpose, and 7) developing integrity. As we coded the data, we identified an additional, emergent code of "self-awareness," which we inductively added to our list of codes (Miles et al., 2020). In a second round of coding, we parsed out sub-codes within the parent codes to help us better understand the aspects of each vector that students self-reported experiencing. To increase the validity and reliability of our results, we coded all data sources together, allowing us to reconcile in the moment any potential differences in coding. The following section presents preliminary findings from our analysis.

Results

Identifying which vectors participants experienced in their role as LAs is an important first step to developing a richer understanding of how wider professional learning experiences can influence PST development. As such, we were interested in the codes that were most highly saturated in the data. Moving through autonomy toward interdependence, developing mature interpersonal relationships, developing purpose, managing emotions, and developing integrity were each coded less than 25 times. Of the seven vectors, the remaining two codes, developing competence (coded 85 times) and establishing identity (coded 41 times) surfaced as the most highly saturated codes in our data, so we sought to further examine what it was about these codes that participants identified surfacing within their LA experiences to better understand how we might leverage such experiences to maximize identity development.

Developing Competence as Future Teachers: Mastering Content, Pedagogy, and Relationships

Chickering sub-divides the vector "developing competence" into several components, two of which surfaced regularly in our data: intellectual competence and interpersonal competence.

Intellectual competence is defined as including the ability to master content, develop sophistication related to intellect and aesthetic, and build a wide range of skills, whereas interpersonal competence involves the acquisition of communication skills such as listening, cooperating, and communicating and responding effectively (Chickering, 1969; Chickering & Reisser, 1993). These sub-codes were the most frequent in our data, with 63 instances of intellectual competence and 22 instances of interpersonal coded, thus we wanted to tease out the aspects of participants' experiences as LAs that resulted in their sense of gained competence.

Intellectual competence. We uncovered several common themes in our analysis of the sub-code of intellectual competence. First, multiple participants described development of their ability to recognize (and sometimes employ) effective strategies for engaging learners in the classroom. One participant reflected on their experiences in an active learning classroom, stating,

> As a LA I have an opportunity to, it's a very interactive class and so I'm having one on one conversations with students or having group conversations with this group and learning a lot about how to guide students' thinking without giving them the answer. I think that's been a big takeaway from the LA experience (Focus Group Interview).

For several of the participants, this was their first-time experiencing mathematics instruction in an active learning environment, as either a learner or a teacher, and it pushed them to rethink their understanding of the structure of a mathematics lesson at the undergraduate level.

This led into our second observation that multiple participants discussed the ways in which observing their mentor teachers' teaching style influenced their thinking about mathematics instruction. They identified specific teaching structures and strategies their mentors utilized, as well as the impact it had on students in their classroom. Participant A explained it thus,

> I have been trying to analyze and pick apart [my mentor's] teaching style… because he is a phenomenal teacher and I want to be the same for my students. One big thing I have noticed is that he… tells the students to do something alone for a couple minutes, then discuss with their partner for a minute, then their group for another minute. He does this everyday… Everything he does is consistent, and it reflects on the students' engagement and learning. (Learning Assistant A).

In addition to thinking about how content is delivered, participants also reflected on the depth of mathematics content knowledge they would be required to have as future mathematics teachers and how to make mathematical connections obvious for their students. A participant described one instance of this he experienced while observing, saying,

> I am going to reach out to my mentor that I am teaching with and ask if they would share the lesson plan ahead of time. This way I can study up on the mathematics I know but forget due to the length of time it has been since I learned or used it. Just because I learned it before, does not mean that it is permanently retained. More practice and re-learning can solidify the mathematics in my brain though (Learning Assistant B).

These recurring themes around intellectual competence illustrate the potential power of using learning assistantships to help students develop mathematical content and pedagogical knowledge for teaching (Ball et al., 2008). As participants continue in their preparation program and future practicum experiences, having the opportunity to recall these WPEs as LAs can help them be more conscious of their teacher actions and leverage their own experiences to help their students learn (e.g., Darling-Hammond & Bransford, 2005; Sleeter, 2018).

Interpersonal competence. In addition to developing intellectual competence, participants also reflected on how their experiences as LAs influenced growth in their interpersonal competence, or their ability to communicate and collaborate effectively, in approximately one-fourth of segments coded for this vector. As participants engaged in conversations with their mentors and with the students in the mathematics courses they assisted as LAs in, they reflected on how these opportunities allowed them to develop their capabilities to engage with colleagues and students.

One aspect of this competence arose through comments that indicated the LAs' learning about the importance of fostering positive relationships with the students in their classes. Receiving advice about how to do this in mathematics courses from veteran instructors can help to develop this vector in preservice teachers. Providing additional and early access through LA experiences can offer these novice teachers more chances to reflect on this. As one LA shared,

> This past week I was able to get to know my mentor teacher…we discussed… her past experiences as a teacher and what I had experienced so far as a future teacher… Her biggest piece of advice was to try and build relationships and trust with the students I will work with… I know that I will have to find my own way here, but hearing examples of what has worked for others helps a bit (Learning Assistant C).

Recognizing the potential impact that the trust and rapport that comes of this relationship building can have on student engagement in mathematics courses was uplifted by another participant, who said, "I want to get to the point where the students become comfortable with explaining their thought process through the work to me. My goal is to increase the student's ability to discuss ideas and their confidence in math" (Learning Assistant D).

Another aspect of interpersonal competence that arose in the data was the idea of vulnerability in front of students as a way to build trust. One participant described this by saying,

> I have gotten more confidence in myself ironically when I'm able to admit when I'm not confident. We were learning about [a math strategy] ... I had never really seen before and… just being real with the students and saying, hey listen, this is not how I learned it when I took this class… and I think the students actually really appreciated that because a lot of them found it really confusing as well. So, I think just, I learned about myself to be more open and straightforward with the students (Learning Assistant E).

This notion of "humanizing" mathematics and the faculty who teach mathematics courses is perhaps a novel revelation for PSTs, who may historically think of the teacher as being the "expert" in all aspects of their field, especially STEM areas (Aguirre et al., 2013; Allen & Schnell, 2016). Taken together, participants recognized that being a "good" mathematics teacher involves more than knowing content, it also requires them to know their students and vice-versa.

Establishing Identity as Future Teachers: Developing a Professional Identity

Establishing Identity was the second most saturated code in our data, with this parent code identified a total of 41 times across the data. Within the larger code of establishing identity, we nested several sub-codes: professional/teaching identity, social or group identity, personal identity, and identity threats. Of these, professional/teaching identity was overwhelmingly the most often coded in the data with a total of 25 counts coded, or just over 60% of the segments (social group and identity threats coded only six times each, personal identity coded only 4 times). A crucial part of helping undergraduate students make the shift from their identity as "student" to their identity as "teacher" is providing them opportunities to gain knowledge of the praxis of teaching and strategies, and also to gain authentic experiences to implement such skills and strategies in real-time. Although most teacher preparation programs offer field experiences where PSTs work in classrooms with students, there is no guarantee that all field placements are with experienced mathematics teachers who incorporate research informed teaching practices, such as active learning and teaching through inquiry. Supplementing these more traditional teaching apprenticeships with learning assistantships can offer PSTs in mathematics rich opportunities to develop not only their praxis, but their self-image as a teacher practitioner.

Participants recognized the importance of this, as well as the impact of engaging as LAs on their professional identities as future teachers. One LA summarized this by saying,

> Additionally, it helps us grow our “teacher voices,” which has been my biggest growth. When I presented my first proof to the class, I was nervous to talk in front of others. Now, with my most recent presentation, I was much more confident, was able to face the class and present from the board and engaged with my peers. I noticed my voice was more confident… (my “teacher voice”!). I believe I am more confident now because I have found my ‘place’ in the class and have gotten to know my peers and professor more, which helps me understand what type of presentation and engagement I should do (Participant F).

Our findings support previous research finding that learning assistantships develop both content understanding and their identity as a future professional (Hall, 1974; Tunks & Weller, 2009). In part, our data show that participants’ ability to find their voice, communicate their thinking, and work with others helped them see themselves more as teachers and leaders in the classroom (Close et al., 2016; Goff & Lahme, 2003).

Applications to/implications for teaching practice or further research

Findings from this study support that learning assistantships are advantageous WPE that support the development of PSTs competence and professional identity as second mathematics teachers. In particular, these early program and full semester LA experiences are unique factors of this program design that have the potential to accelerate PSTs development. These LA experiences also provide intentional mentor pairing that are often challenging to control in traditional teacher preparation programs. The sample size and data set presented here are small and lack diverse representation of student participants. However, this study indicates the need for research on the impact of LA opportunities on PST development in mathematics and other STEM areas. This work does add to the body of existing research in this area and presents elements of this apprenticeship model that are important to focus on in future studies:

- leveraging learning assistantships to develop PSTs content and pedagogical knowledge of teaching secondary mathematics using active learning strategies;
- utilizing learning assistantships as models for how to foster positive, trusting relationships with students and allowing LAs to examine its impact on student engagement and achievement; and
- providing additional structured, scaffolded experiences teaching mathematics to facilitate PSTs’ sense of “teacher self.”

Future work has the potential to extend to other STEM education content areas, which can help to generalize the benefits and challenges of using learning assistantships to develop undergraduate PST identity and support the learning outcomes of mathematics students learning side-by-side with their near-peers as guides.

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